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PART PLAYED BY TILLAGE EQUIPMENT AND TILLAGE METHODS ON YIELD OF COTTON ON ~~RED BAY FINE SANDY LOAM~~

Statement by John W. Randolph, Agricultural Engineer,
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A review of the publications covering cotton research investigations indicates that tillage has been considered an art rather than a science. If we judge by the amount of research work done, it would seem that tillage is of minor importance. However, Table 1, based on Table 496 of Agricultural Statistics 1937, shows that approximately one-third of the cost of producing cotton is made up of seedbed preparation, planting, cultivating and hoeing. These are all tillage operations and unless planned and executed advantageously may hinder the farmer in following a profitable diversified crop program as well as cut the yield of cotton. The price the farmer gets for his cotton depends on the market and is out of his control, but the costs of producing it are to a considerable extent in his hands.

Most of the present research work on cotton production is directed toward seed improvement and the use of fertilizer. Although these items are undoubtedly of great importance, is it fair to the cotton farmer to conduct research only on these phases of cotton production and neglect studies of tillage, an item that makes up one-third of his production cost? As a result of this neglect of tillage research, our common field practices of seedbed preparation, use of power, etc. are about as developed by our resourceful pioneering farmers and machinery designers. They have necessar-

ily based their programs and equipment on observations rather than on exact measurements.

The present generation of men interested in developing farm equipment have made outstanding contributions, but there is still much room for improvement in tools and methods suited to particular soil conditions and crop production programs. Improvement in tillage methods will come by slow degrees if we continue to place dependence on isolated single-objective studies. The time is now ripe for a comprehensive cooperative research program. The joint efforts of many of the scientific branches of agriculture are needed to determine the relation between crop growth and soil manipulation, so that the manufacturer, on the basis of such information, can provide tillage tools better suited to particular farm conditions.

Studies of cotton production machinery and cotton tillage methods were started in 1930 by the U.S. Bureau of Agricultural Engineering and the Alabama Experiment Station. One phase of this investigation consists in field experiments begun six years ago upon Red Bay fine sandy loam near Prattville, Alabama. These experiments were designed to evaluate in cotton production, labor and power requirements, 37 conventional methods of seedbed preparation, several methods of cotton planting, and 24 methods of cultivation. Check plots were placed at definite intervals to check soil veriability. Fertilizer, seed and similar non-tillage factors were kept constant on all plots. Studies of seedbed preparation, planting and cultivation were conducted separately, that is, only one group of variables was studied on a series. All seedbed preparation plots were planted and cultivated alike, and all cultivation experiments started on land uniformly prepared and planted.

The findings set forth will have more or less direct application to several million acres of the coastal plains soils that have textural and structural properties similar to this Red Bay fine sandy loam though classified under other names.

Seedbed Preparation

The variations in seedbed preparation were obtained by following conventional field practices, working the soil in the fall, in the winter, or in the spring, and by deep (approximately 8 inches) or shallow (approximately 4 inches) use of a few common implements. Table 2 gives the results of a few of the variations in seedbed preparation studied.

A group of plots in which the seedbed preparation consisted in hand pulling and breaking the old cotton stalks and chopping out the weeds with a hoe were used as a base or check for measuring the effect of the operation used on other plots. The yield of the check plots was 1,100 pounds of seed cotton, method 402, table 2, but it must be borne in mind that, though this method gave a fair yield, the cost and hours of hand labor required for removing weeds and handling the old cotton stalks would be prohibitive to the farmer.

The usual farm practice is to wait until spring to start seedbed preparation work and then by shallow working produce a nicely rounded loose seedbed just before planting. Such a practice may be represented by method 411, Table 2, which makes a fine looking seedbed, but tends to produce a 'plow sole'. This method produced only 38 pounds of seed cotton more than no tillage, giving a return of only 2.9 pounds of seed cotton per horsepower hour spent in seedbed preparation. Method 612, Table 2, often called 'planting on the hard', shows an average loss of 76 pounds in seed cotton per acre for the shallow busting work done in the row middle.

Busting out the old row, then bedding back the row by busting out the old middles (method 609, Table 2) produced 35 pounds more cotton than the base method for shallow spring work. The same operations carried on 8 inches deep (method 509, Table 2) yielded 138 pounds more than the base method. Adding the use of a 9-inch plow to throw two furrows onto the first busted furrow, often called 'box bedding' (method 608) to the operation listed in method 609, showed a decrease of 23 pounds of cotton for shallow work. A similar comparison between methods 508 and 509 showed a gain in yield of 9 pounds in favor of the two extra furrows. "Box bedding" completed in the winter, as on methods 607 and 507 (Table 2), gave increases of 47 pounds for the shallow work and 112 pounds for the deep work over base plot 402. Broadcast plowing with good inversion has proved beneficial in the control of many annual weeds. The winter 8-inch plowing on method 501 has excelled all methods studied in average yield. Plowing 4 inches deep in winter (method 601) produced 137 pounds less cotton than plowing 8 inches deep (method 501). Both methods show good returns for the power used. The increase in yield of methods 507 and 501 expressed in pounds of cotton per horsepower hour is 8.1 and 8.8 respectively which is of double significance. They are profitable operations, and they enable the farmer to get his seedbed preparation out of the way in the winter so there will be time available for other work in the spring.

The five-year average yields for all methods of seedbed preparation used varied from 959 to 1,333 pounds of seed cotton per acre. This difference of 374 pounds per acre is believed to be primarily due to the differences produced in the soil structure. The power required to prepare an acre of cotton land by the different methods studied varied from 0 to 93 horsepower hours. The time required to keep down weeds, chop and do other hand opera-

tions, except picking, varied from 18 to 122 man hours.

The results show that a cloddy seedbed produced by working the soil deep when relatively dry and then allowing it to settle and mellow some time before planting produces more cotton than shallow or excessive tillage operations. Thus it is indicated that the primary value of tillage is in helping natural agencies produce an optimum 'tilth', and that excessive pulverization destroys desirable soil structure conditions. The seedbed preparation methods producing the best cotton caused the soil to maintain an open granular structure throughout the crop season as shown by detailed measurements of the soil's physical condition. It was noted that for such a soil condition the cotton yield was affected the least by dry weather during the growing season. It will be found, however, that soils vary in their ability to assume a semi-permanent structure that will aid crop production. The methods found best on this type of soil may not be best for other types.

Preliminary studies of lint cotton produced upon different types of seed beds and with varying depths of cultivation indicate that there is a variation in the staple characteristics. The cotton of low value appears to be associated directly with excess soil pulverization and late work. Cotton of good character and staple seemingly is associated for the most part with a cloddy soil structure made in the winter when the soil was dry. This is the type of structure that produced the best yields.

The results show that the most economical cotton production was not obtained with the extreme tillage, but with methods that are very practical with moderate size power units. The difference in rates of yields are significant, but true evaluation of the results for a given farm depends on the extensiveness or the intensiveness of the tillage to be performed, as

controlled by the availability of labor, power and land, and by the farming program.

Cotton Planting

About fifty percent of the cotton had to be replanted each year on those farms adjoining Prattville Field where conventional planting methods were used. The Bureau's variable depth system of cotton planting was used on all tillage experimental plots and an ample stand was obtained with the first planting on each plot each year. The Bureau's one-operation method of cotton planting consists in cutting the seedbed to the desired height with a sweep shaped to give the bed a slight crown and then planting the seed with the variable-depth planter. If desired, side placement of fertilizer can be made in the operation. This planting method should be considered by the farmer as a means of taking one of the gambles out of his cotton production.

Cotton Cultivation

Cotton cultivation studies consisted in variations in row work and cross row methods. In the early stages of cotton growth cross cultivation operations were used as shown in Table 3. The principal feature of this table is that cross row cultivation with the rotary hoe and weeder can be performed on Red Bay fine sandy loam soil several times without destroying the stand. The practical value of these low cost machine operations is that they make it possible to lengthen the normal chopping period, thus permitting a small hoe labor crew to carry on the necessary cleaning, spacing, and thinning of the cotton plants. The cross cultivation operations as studied will not be satisfactory on land infested with Johnson grass, nut grass, or weeds coming from large seeds.

Row cultivation data in Table 4 show that cultivation should be shallow and just sufficient to keep down weed growth. The old adage which says that cotton should be cultivated "a furrow per row per week" is without foundation.

The recommendation, based upon the data and on land free of Johnson grass, nut grass or large weeds, is to start early cross-row cultivation soon after planting to keep down weeds, break the soil crust, and to help bring the cotton to a stand of strong plants; then, after chopping, follow with shallow row cultivation frequently enough to control weeds.

Legume Coverage

The growing of winter legumes in the South has proved profitable. Extension of this practice depends largely upon the ability of the farmer to turn under a greater acreage of cover crops in the limited time available for such work. The Bureau has completed a 2-year study of different methods of turning under and killing the winter legumes as an operation in seedbed preparation for cotton. Complete records of yield for only 1936 are available at this time, but the incomplete 1937 records indicate the results will confirm those of 1936 which showed marked variation in yields by the different methods. The results to date indicate the need and importance of a comprehensive research program on legume coverage.

Summary

Test data show that upon Red Bay fine sandy loam the tillage methods and equipment can markedly influence cotton yields, cost of production, and profit.

The results cover only a few types and sizes of tillage tools used in cotton production. It seems probable that a comprehensive study of tillage machinery design and of utilization on different soil types will bring out greater contrasts than those so far obtained.

TABLE 1

PERCENTAGE DISTRIBUTION OF ESTIMATED COST OF COTTON PRODUCTION, 1935

(Basis: Table 496 Agricultural Statistics, 1937, U.S.D.A.)

Region	Group I: Prepare, plant, cultivate, and hoe.	Group II: Fertilize, manure, and seed.	Group III: Harvest and gin	Group IV: Miscellaneous and land rent
Coastal Plain	30.20	17.53	27.93	24.34
Piedmont	31.05	18.42	25.93	24.60
Eastern Hilly Areas	34.50	13.73	25.29	26.48
River Bottom Areas	30.86	5.56	32.84	30.74
Western Hilly Areas	38.00	8.38	26.66	30.96
Gulf Coast Prairie and Texas Black Prairie	34.38	5.64	23.39	36.59
Western Dry Areas	29.83	4.93	35.36	29.88
Irrigated Areas	22.58	2.50	35.56	39.36
United States	32.27	10.27	27.90	29.56

TABLE 2
EFFECTS OF SEEDBED PREPARATION METHODS ON RED BAY FINE SANDY LOAM ON YIELD OF COTTON

Uniform Cultivation — Prattville Field 1932-36

Method No.	Machine Operations. (With disk harrow, 10" middle buster, 9" and 14" moldboard plows)	Approximate date of work	Equivalent draft per 40" row in pounds	5 Year Average Data: Horsepower hours per acre	5 Year Average Data: Seed cotton in pounds 1/ per acre
402	No machines used; stalks hand-pulled, weeds hoed out, 44 man-hours per acre. Cultivated as other plots.		---	0.0	1,100
411	1. Double disk	March 1	720		
	2. Double disk	March 20	800		
	3. Bust middle 4" deep	March 30	210		
	4. Knock down beds 2/	April 15	200	12.7	1,138
612	1. Cut stalks	Fall	250		
	2. Bust middle 4" deep	Dec. 20	320		
	3. Pull roots (12 hr/acre)				
	4. Knock down beds 2/	April 15	160	4.9	1,024
609	1. Cut stalks	Fall	250		
	2. Bust out old row 4" deep	Feb. 20	360		
	3. Bust middle 4" deep	March 20	380		
	4. Knock down beds 2/	April 15	160	7.6	1,135
509	1. Cut stalks	Fall	250		
	2. Bust out old row 8" deep	Feb. 20	1,110		
	3. Bust middle 8" deep	March 20	1,480		
	4. Smooth	April 15	460	21.8	1,238
608	1. Cut stalks	Fall	250		
	2. Bust row 4" deep	Feb. 20	350		
	3. List back two furrows 4" deep	March 20	660		
	4. Bust middle 4" deep	April 1	380		
	5. Smooth	April 15	170	11.9	1,112
508	1. Cut stalks	Fall	250		
	2. Bust tow 8" deep	Feb. 20	1,130		
	3. List back 8" deep	March 20	1, 740		
	4. Bust middle 8" deep	April 1	1, 160		
	5. Smooth	April 15	590	32.1	1,247

TABLE 2 (Cont'd)

EFFECTS OF SEEDBED PREPARATION METHODS ON RED BAY FINE SANDY LOAM ON YIELD OF COTTON

Uniform Cultivation — Prattville Field 1932-36

Method No.	Machine Operations (With disk harrow, 10" middle buster, 9" and 14" moldboard plows.)	Approximate date of work	Equivalent draft per 40" row in pounds	5 Year Average Data: Horsepower hours per acre	5 Year Average Data: Seed cotton in pounds per acre 1/
505	1. Cut stalks	Fall	250		
	2. Bust row 8" deep	Feb. 20	1,150		
	3. Subsoil with 3" furrow 8" deep	Feb. 25	1,380		
	4. List back 8" deep	March 20	1,840		
	5. Bust middle 8" deep	April 1	1,160		
	6. Smooth	April 15	470	41.3	1,258
607	1. Cut stalks		250		
	2. Bust row 4" deep	Jan. 10	320		
	3. List back 4" deep	Jan. 30	480		
	4. Bust middle 4" deep	Feb. 15	210		
	5. Smooth	April 15	210	9.7	1,147
507	1. Cut stalks		250		
	2. Bust row 8" deep	Jan. 10	1,090		
	3. List back 8" deep	Jan. 30	1,400		
	4. Bust middle 8" deep	Feb. 15	820		
	5. Smooth	April 15	390	26.0	1,312
601	1. Cut stalks	Fall	250		
	2. Plow broadcast 4" deep	Jan. 10	1,230		
	3. Bed with cultivator 3/	April 1	310		
	4. Smooth	April 15	120	12.6	1,196
501	1. Cut stalks	Fall	250		
	2. Plow broadcast 8" deep	Jan. 10	3,340		
	3. Bed with cultivator 3/	April 1	280		
	4. Smooth	April 15	120	26.3	1,333

1/ Weighted for soil variability and average of two plots, except 601 and 501 average of 8 plots which are used as checks to measure soil variability.

2/ Wooden drag float used to knock off bed top for conventional planting.

3/ Bedded with cultivator equipped with 4 - 14" disk hillers per row.

TABLE 3

EFFECT OF CROSS-ROW CULTIVATION FOLLOWED BY SHALLOW SWEEP CULTIVATION ON YIELD OF SEED COTTON ON RED BAY FINE SANDY LOAM

Series 300 — Prattville Field 1932-36

Cross Cultivation	Number of replications	Average yield of seed cotton per acre in pounds 1/	Average time for chopping per acre
2 Drag Harrow	2	1,295	9.2
3 Drag Harrow	2	1,272	9.0
5 Drag Harrow	2	1,268	8.2
2 Rotary Hoe	2	1,215	9.5
3 Rotary Hoe	2	1,347	9.5
5 Rotary Hoe	2	1,311	8.6
2 Weeder	2	1,331	9.6
3 Weeder	2	1,316	9.6
5 Weeder	2	1,340	7.6
1 Cross Blocked	2	1,207	9.7
1 Hoed during test period	9(check)	1,337	8.2

1/ Weighted for soil variability by checks.

TABLE 4

EFFECTS OF METHODS OF ROW CULTIVATION ON YIELD OF SEED COTTON ON RED BAY FINE SANDY LOAM

Series 100 — Prattville Field 1932-36

Cultivation	Number of replications	Average hours of Machine Work	Average hours of Hoe Work	5 Year average yield of seed cotton per acre 1/
Hoe only	2	---	62.8	1,195
3 Shallow - sweeps	2	5.8	14.2	1,246
6 Shallow - sweeps	6(check)	11.3	12.1	1,224
12 Shallow - sweeps	2	21.2	12.0	1,226
6 Deep - shovels	2	14.4	12.3	1,181
3 Deep and 3 shallow	2	12.8	12.7	1,232
3 Shallow and 3 deep	2	13.1	12.6	1,193
6 Turn plow and middle buster	2	----	17.9	1,139

1/ Weighted for soil variability by checks.